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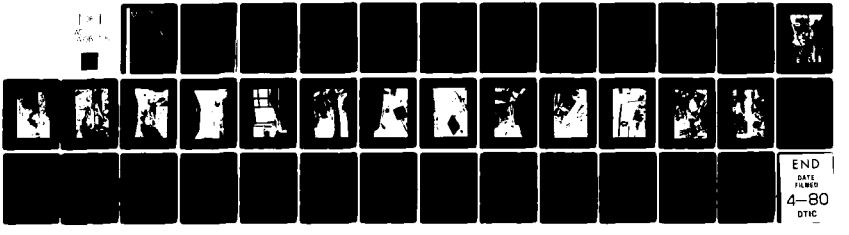

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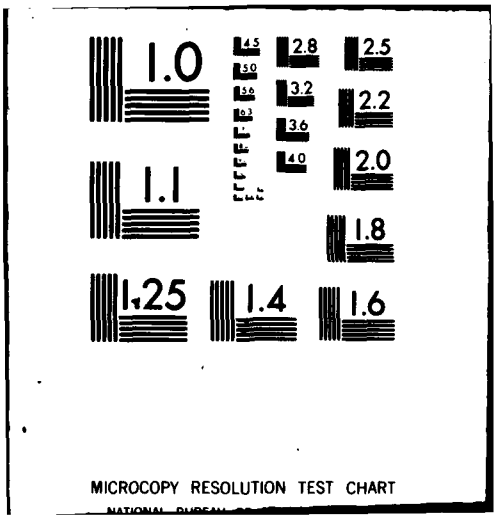
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RESEARCH AND DEVELOPMENT TECHNICAL REPORT
CORADCOM-

COMMUNICATIONS - ELECTRONIC INTRASYSTEM ELECTROMAGNETIC INTERFERENCE MEASUREMENT TECHNIQUES AND INSTRUMENTATION

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January 1980

Quarterly Report for Period 20 June 1979 — 20 September 1979

Approved for public release; distribution unlimited

Prepared for:
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results obtained during the first quarter of the Communications-Electronic Intrasystem Electromagnetic Interference Measurement Techniques and Instrumentation project. The period covered was 20 June 1979 to 20 September 1979. The major effort in the first quarter consisted of a literature search, report reviews, site visit to Fort Knox to examine armored vehicles for MIL-STD-461A and -462 evaluation and an initiation of the feasibility of IEMCAP as an EMI/EMC analysis tool for system measurements.

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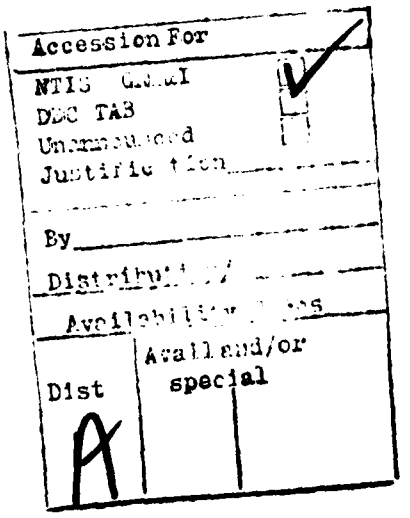

1. INTRODUCTION

The purpose of this contract is to develop an improved approach to the communication-electronic system integration problem from an EMI standpoint. Specifically, the effort is directed toward investigating the use of computerized analytical tools such as IEMCAP in conjunction with the overall EMI test procedures of MIL-STD-461A and -462 to develop a more meaningful and economical approach to defining the system EMI problems. The analytical techniques will provide guidance and insight into the system characteristics which will allow for effective utilization of measurement resources and time. The results will lead to the establishment of an interactive EMI/EMC analysis and measurement procedure which will provide the basis for a meaningful EMI intrasystem measurement standard.

This is the first of three quarterly reports which will be submitted under this contract. A final report will be submitted at the end of the fourth quarter. Each of the quarterly reports will describe the work accomplished and the progress of the program in the quarter with special discussion reserved for any problem areas and proposed corrective actions for these problem areas.

This is a five-section report. In addition to this introductory section, Section 2 discusses the project background and goals, Section 3 describes the first-quarter events, Section 4 summarizes the work accomplished in the first quarter, and Section 5 describes the work planned for the second quarter of the project.

2. PROJECT BACKGROUND AND GOALS

The overall purpose of the project is to develop measurement techniques which are necessary and sufficient to ensure intrasystem electromagnetic compatibility. An attempt will be made to limit the measurement requirements to those which are necessary and at the same time develop measurememt techniques which are sufficient to ensure electromagnetic compatibility. To accomplish this goal, an analysis program will be utilized as part of the system test procedure. The analysis program will allow a reduction in the number of tests and test points required to evaluate intrasystem EMI.

The effort of using an analysis technique to focus EMI/EMC measurements, in order to obtain more meaningful data in an expeditious manner, is divided into three categories, which in turn are made up of subtasks. The categories are: Analysis, Measurements, and EMI/EMC Considerations.

A. Analysis Subtasks

- Identification of system critical ports, paths and frequencies which must be subjected to measurements.
- Identification of system compatible ports, paths and frequencies which may be eliminated from measurements.
- Determination of background information required on the parameters of frequency, signal type, bandwidth and levels for all system-required and unrequired emission and susceptibilities. The test planning effort should use this information to devise EMI/EMC tests in the most cost-effective manner.
- Definition of the integrated emission and/or susceptibility of individual ports and determination of which ports and paths are redundant so that the total number of system points can be reduced.

- Definition of emission and susceptibility of cable bundles rather than individual wires.

B. Measurement Subtasks

- The use of time-domain measurements, analog-to-digital converters and digital signal processing (e.g., Fast-Fourier Transforms) to measure digital signals, sync. signals, etc.
- The use of wideband measurements and digital signal processing to measure emissions over a broad spectrum.
- Bandwidth matching of the test to the specific characteristics of the emitter and/or the receptor being tested, in order to provide narrowband and broadband testing to be applied as required, rather than to the entire spectrum.
- Measurement techniques to determine the value of the parameters that are required by the analysis program used, which may include power spectral density, integrated margins, etc.
- Cable bundle measurements instead of individual wires.
- Setup of measurement conditions so that results may be extrapolated to other conditions; for example, radiated measurements may be applied to other distances than those actually measured.
- Automated measurement techniques for system-level tests.
- System-level measurement techniques which will accomplish EMI/EMC objectives in the most cost-effective manner.

C. EMI/EMC Considerations

- MIL-STD-461A test requirements will be reviewed and analyzed from a meaningful data production standpoint. A list of tests for system testing in a priority sequence based on value of data will be made. A rationale for the listing will also be presented.
- An accuracy analysis will be performed on the EMI/EMC analytical technique used.
- Transfer functions will be developed to relate data obtained from measurements that are radiated and conducted, near field and far field, and non-standard techniques to standard techniques.
- Presentation of a methodology which can be incorporated into a standard that utilizes the techniques of analysis and measurement developed in this task.
- Develop a plan to verify the methodology presented.

3. FIRST QUARTER EVENTS

The events during the first quarter were:

(1)	Contract Award	20 June 1979
(2)	Kick-off Meeting	25 July 1979
(3)	Field Visit to Fort Knox, KY	2 August 1979.

The program is established for twelve months with quarterly reports due on 20 September 1979, 20 December 1979, and 20 March 1980, and the final report due in June 1980.

The kick-off meeting was held at the USACORADCOM facilities. In attendance were:

USACORADCOM	- Warren Kesselman
	- Paul Major
	- Stuart Albert
Atlantic Research Corporation	- William G. Duff
	- Lester E. Polisky

At this meeting, administrative and technical details for the contract were discussed. It was announced that Stuart Albert would be the USACORADCOM project engineer and Michael J. Pawlish the contract officer. All official contract correspondence must be channeled through Mr. Pawlish. The technical emphasis of the task is the development of measurement techniques for EMI, where analysis programs, such as IEMCAP, are used to focus the attention of the measurement efforts to emission sources or susceptible circuits and components. It was decided that during the first few months of the project, the time could best be spent in a literature and background search, along with the scheduled IEMCAP Feasibility Study and the development of measurement techniques. At the meeting, it was decided to examine a field tank at Fort Knox, Kentucky, at a future date. In addition to the meeting, an inspection was made of various portable shelters used by the U. S. Army to house electronic equipments.

A trip to Fort Knox, Kentucky was made to acquaint project personnel with the configuration of components and wiring of U.S. Army tanks and personnel carriers. In attendance were Stuart Albert of CARADCOM, Clayton Paul of the University of Kentucky, and Randall Ream of Atlantic Research Corporation. The host for the visit was Captain Walker of the U.S. Army Armor Center.

Photographs were taken of the exterior and interior of an M-60 field tank and a personnel carrier. The purpose of the photographs was to show cable runs, structural detail and component installation practices. Figure 3-1 and Figure 3-2 are external views of the tank and personnel carrier respectively. Figures 3-3 and 3-4 are external views of the tank turret. Figures 3-5 through 3-14 are various views of the interior of the tank. The photographs show the type of environment and test points that exist on these vehicles for both measurement and/or analysis considerations.

Project personnel also inspected an XM-1 tank but were unable to photograph it for security reasons. Discussions held with Captain Walker indicated that some of the computerized guidance systems being installed in the new tanks such as the XM-1 are being affected by EMI problems. The type of problems that have arisen relate to inaccuracies in the computer guidance solution. The effects reported are intermittent in nature.

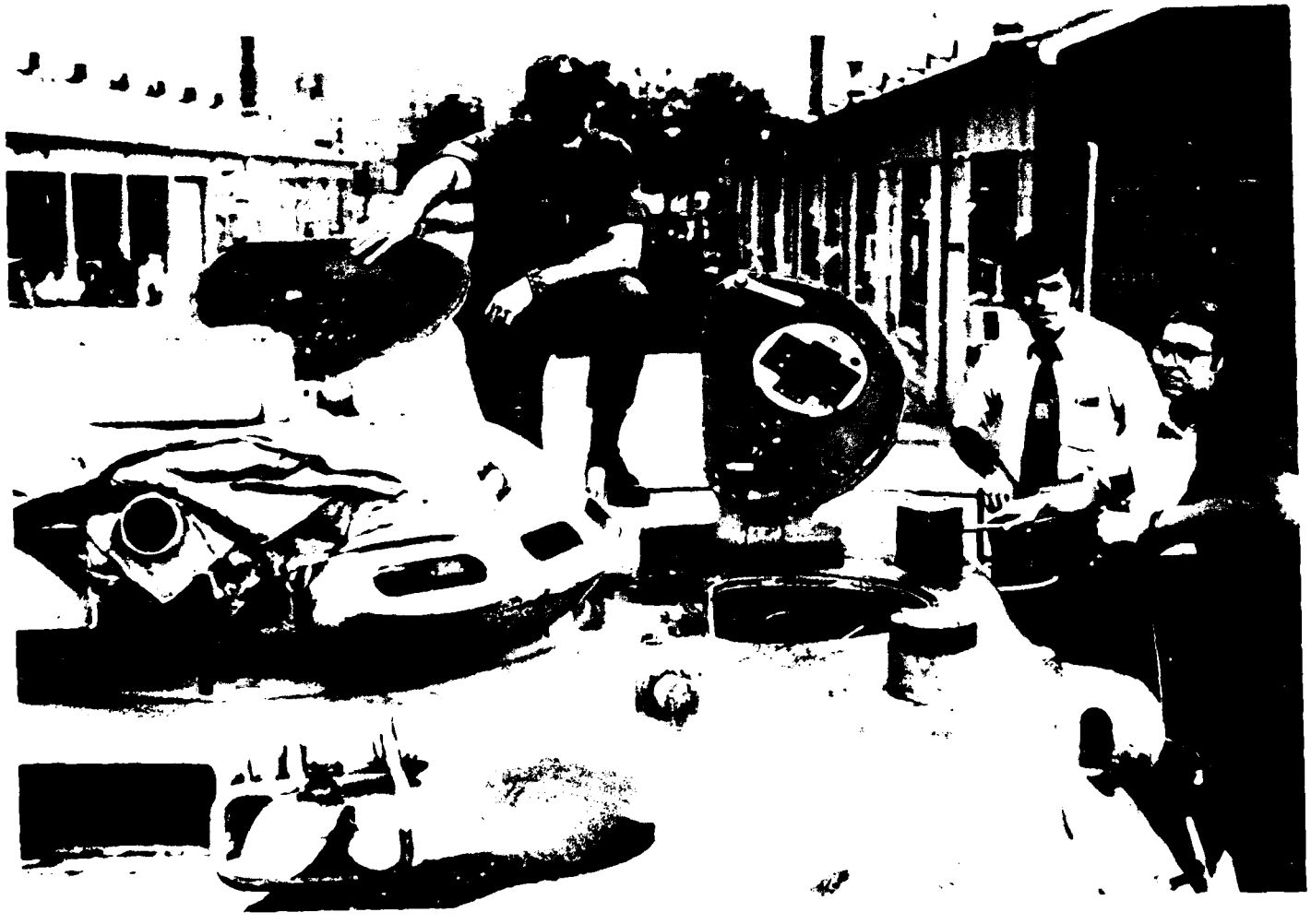

Figure 1. Exterior View of M-60 Tank.

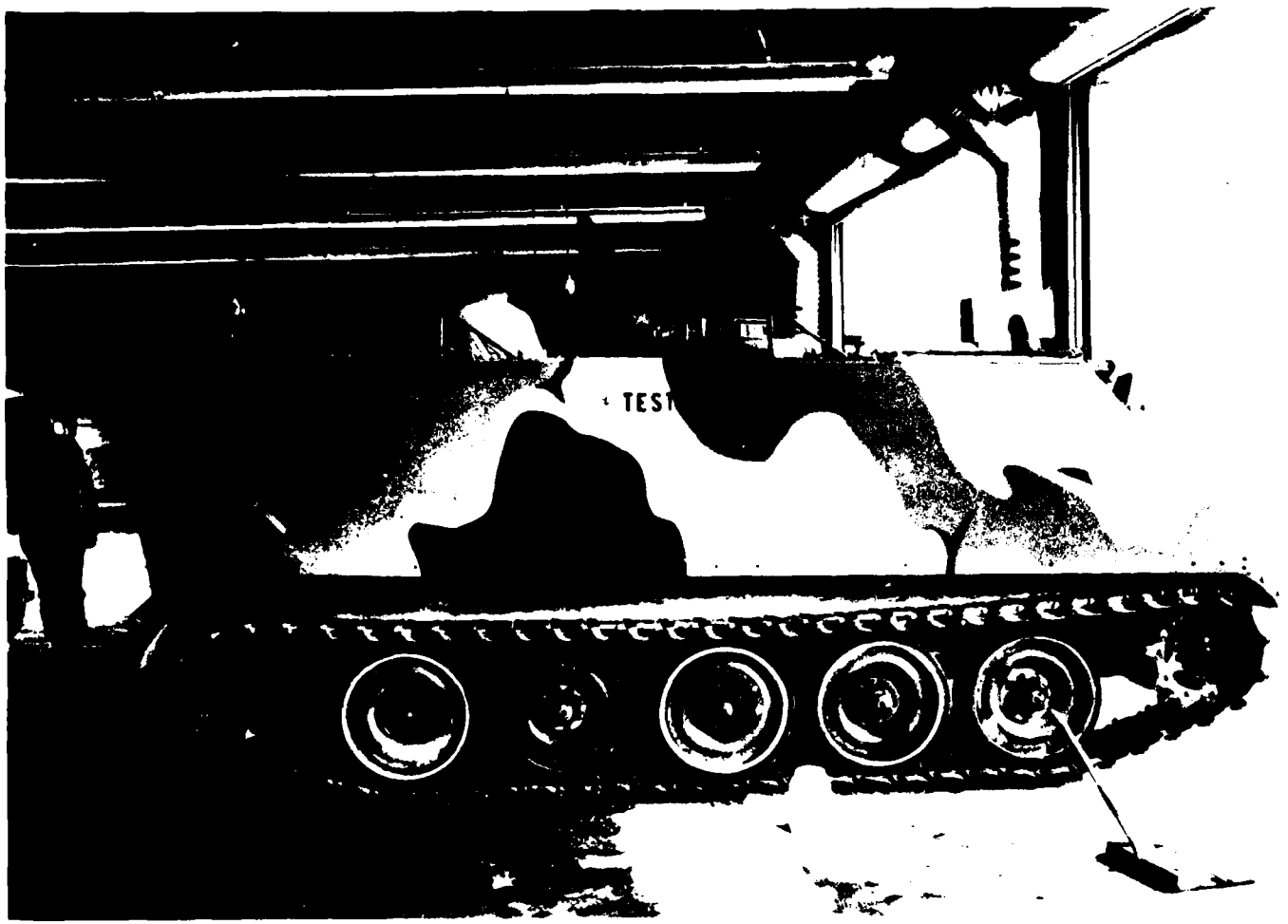

Figure 2. Exterior View of Personnel Carrier.

Figure 3. View 1 of Tank Turret.

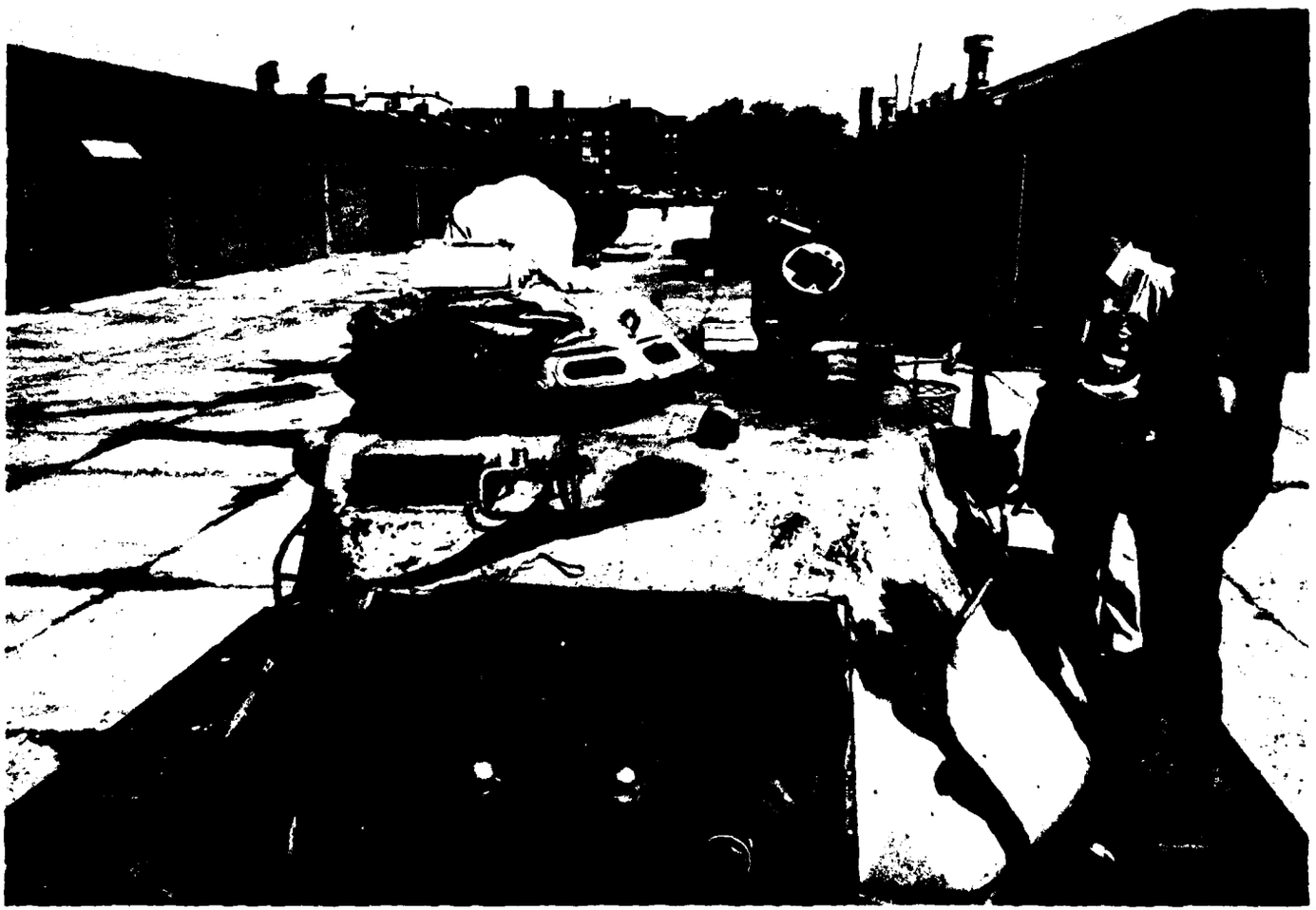

Figure 4. View 2 of Tank Turret.

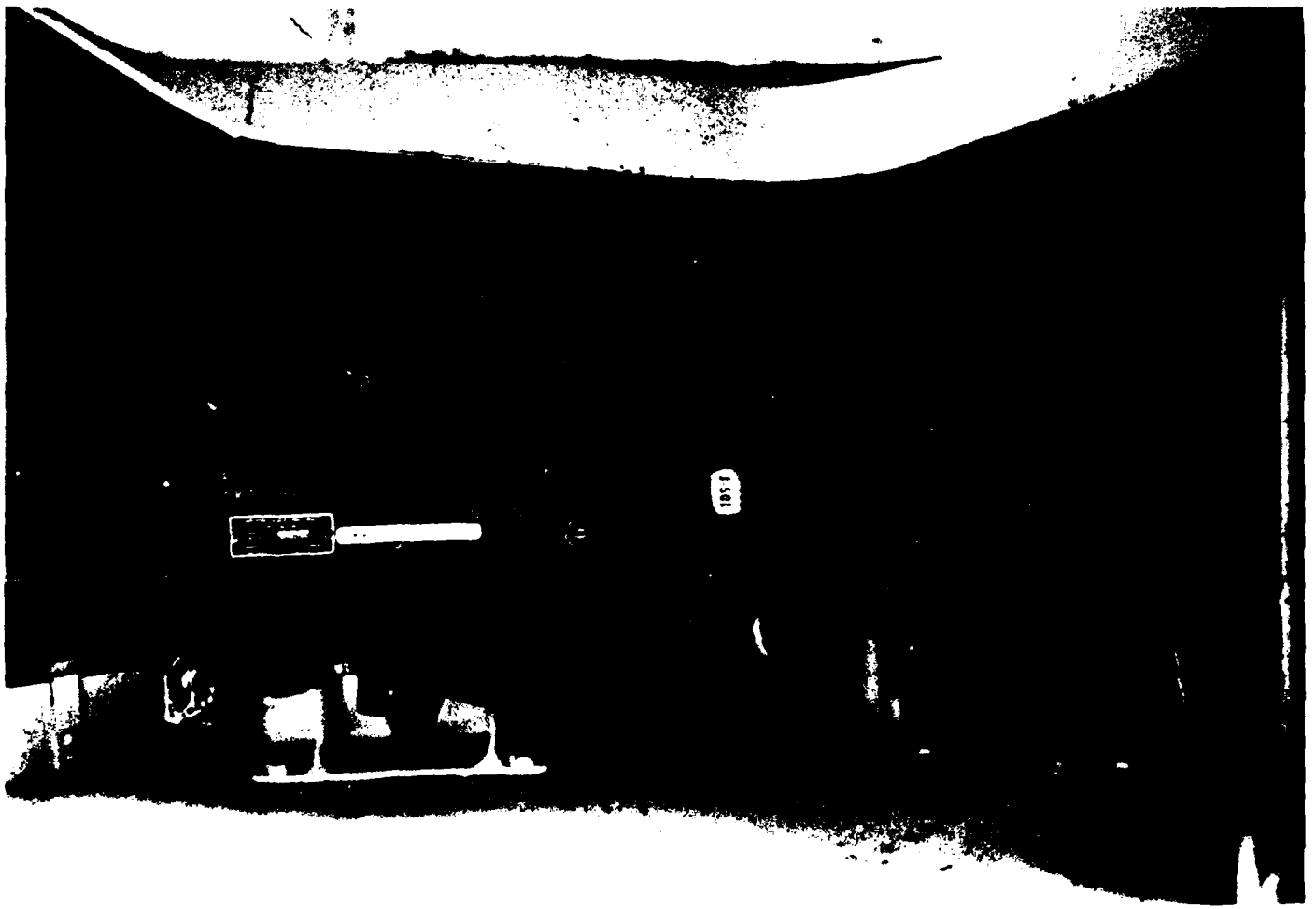

Figure 5. Audio Amplifier, Installed Within the M-60 Tank.

Figure 6. Cables for UHF and VHF Systems.

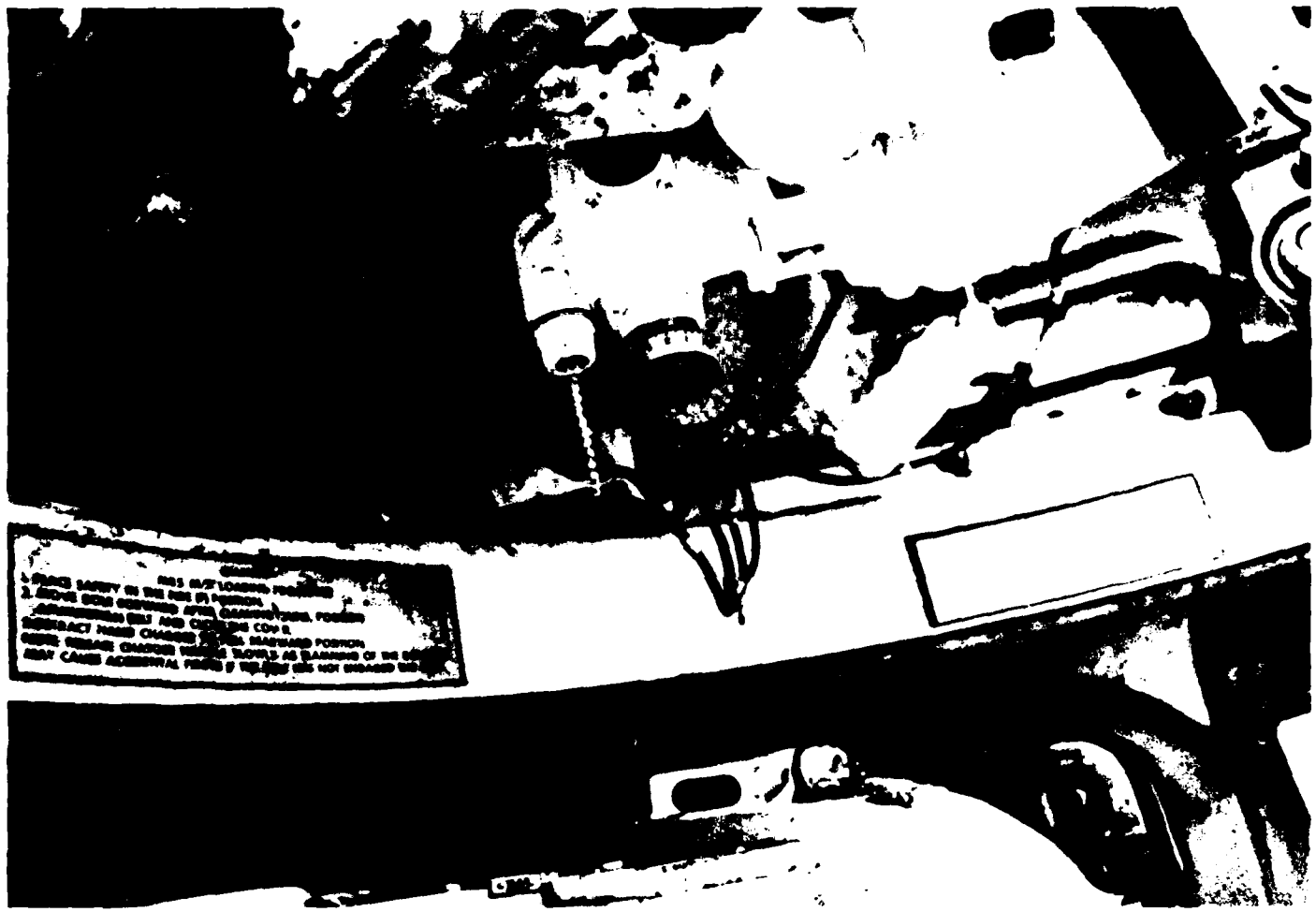

Figure 7. View of Gunner's Position.

Figure 8. Cable Run Along Floor of Turret.

Figure 9. Termination of Cables in Bulkhead.

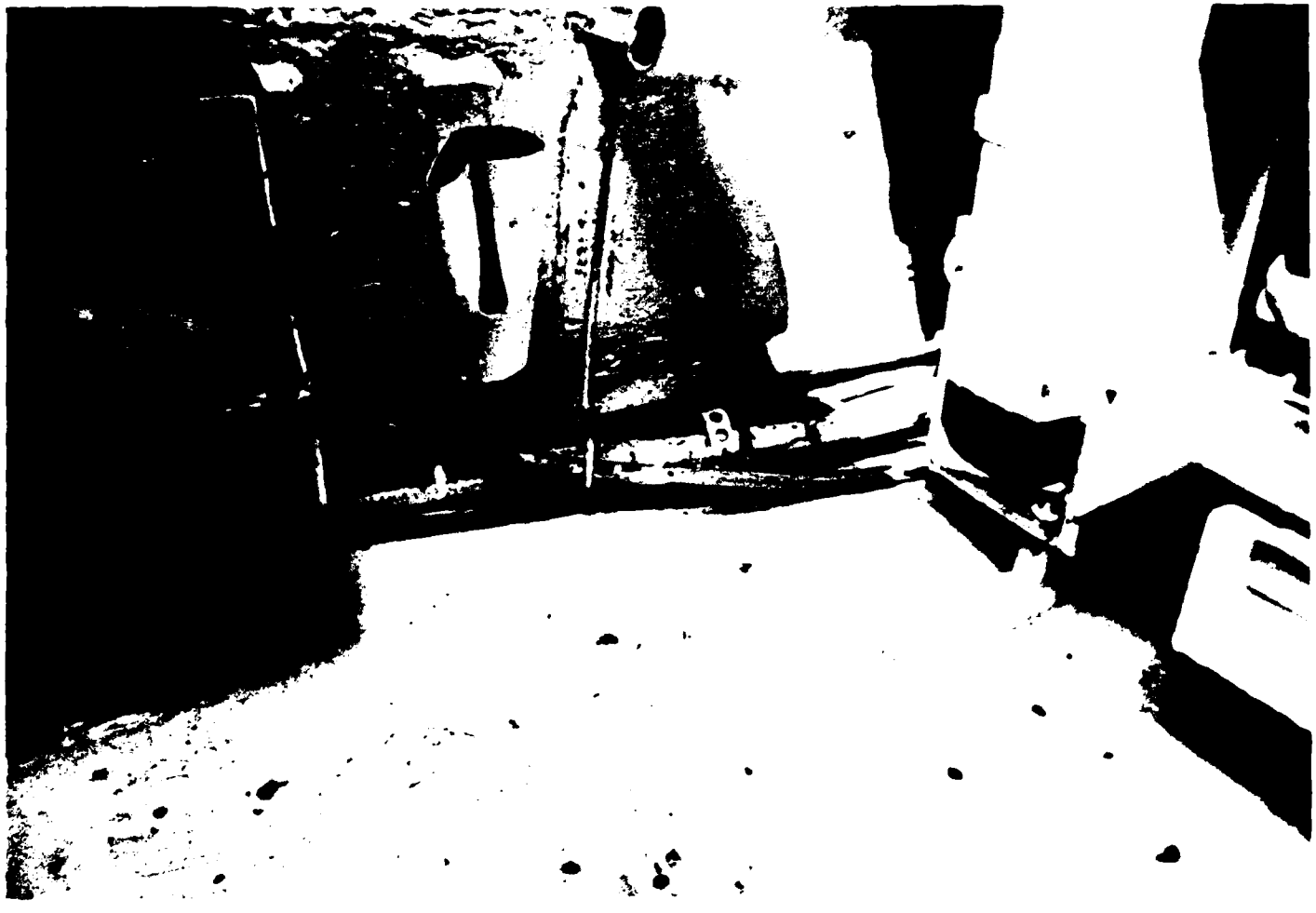

Figure 10. Cable Run Inside Wall of Turret.

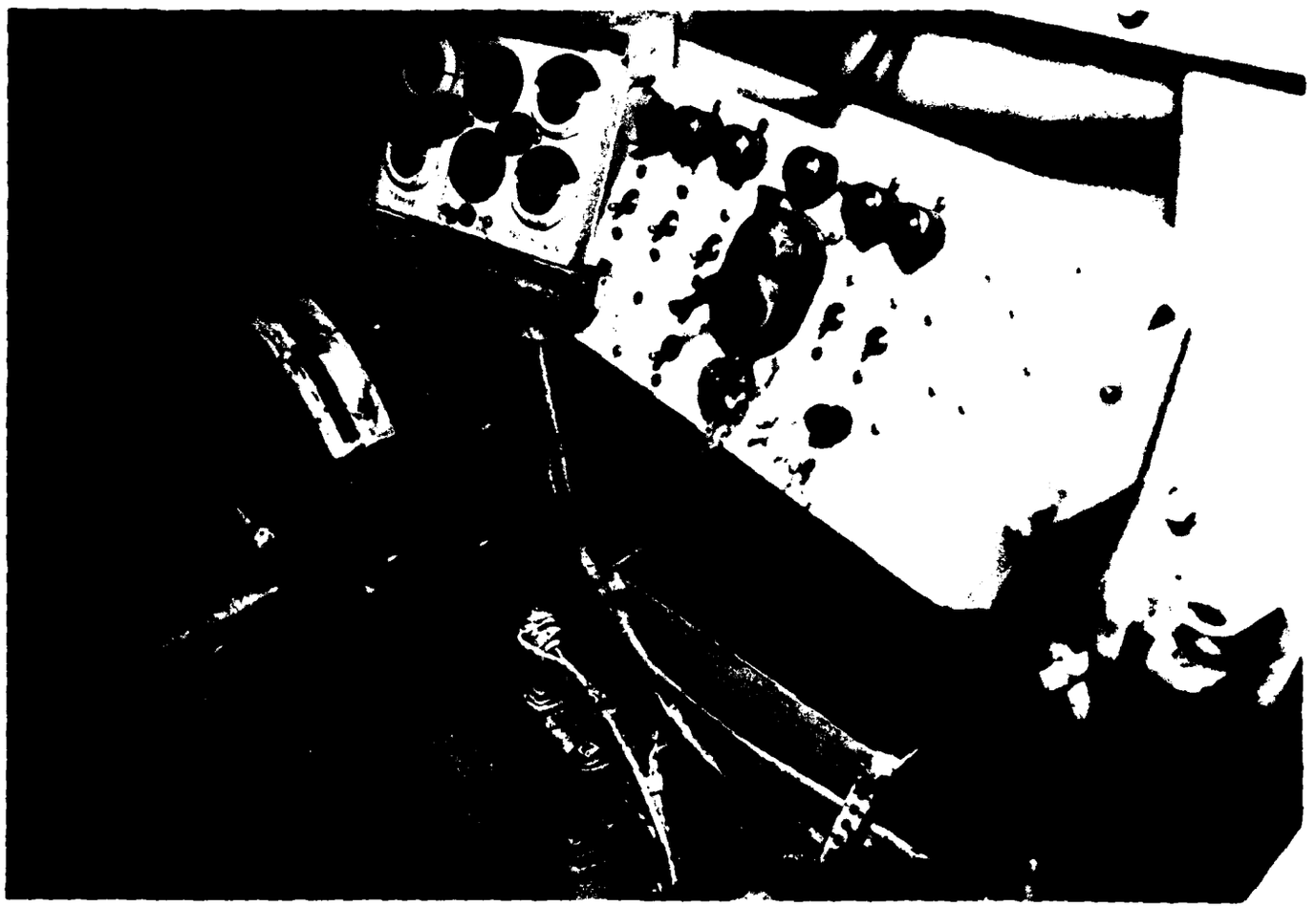

Figure 11. Driver Position Instrument Panel.

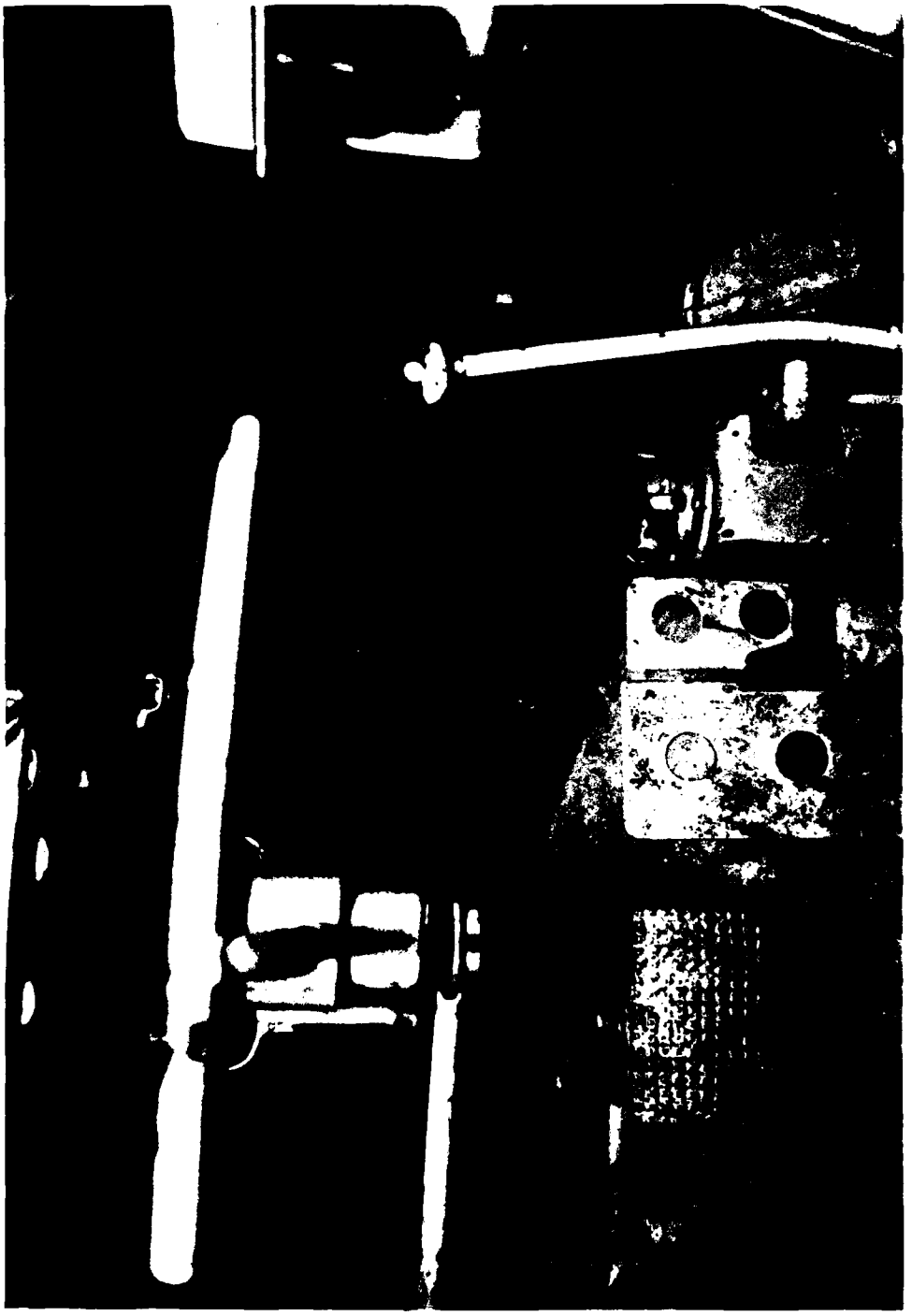

Figure 12. Driver Position Cable Run.

Figure 13. Driver Position Controls and Hydraulic Lines.

Figure 14. Driver Position Cable Runs and Controls.

4. WORK ACCOMPLISHED IN THE FIRST QUARTER

Work during the first quarter has been performed in the areas of measurement technqiues development and analysis program evaluation. For both areas, a literature and background search has been initiated and is continuing. The following reports have been reviewed and are presently in the Project files.

- Millimeter-Wave System EMC Study - First Quarterly Progress Report, Glen G. Sandberg, June 1974, AD 922973.
- Millimeter-Wave System EMC Study - Second Quarterly Progress Report, Glen G. Sandberg, October 1974, AD 923745.
- Millimeter-Wave System EMC Study -Third Quarterly Progress Report, Glen G. Sandberg, Robert F. Marsolais, April 1975, ADB004228.
- U.S. Army Armor Communication-Electronics Data, ST 24-18-1, October 1976.
- Intrasystem Electrogmagnetic Compatibility Analysis Program, Volume I - User's Manual Engineering Section, December 1974.
- Intrasystem Electromagnetic Compatibility Analysis Program Volume II - User's Manual Usage Section, December 1974.

The millimeter-wave system EMC study reports presented useful information on measurement techniques used to collect EMC data at millimeter-wave frequencies. It also contained useful parameter data on both the test equipment setups and the systems measured. The ST 24-18-1 report contains descriptions of hardware and procedures used by armor units. The hardware described includes radio equipment (FM, SSB and AM), aircraft radio, electronic warfare, antennas, radiotelephone, wire communication, radar, radiac and comsec equipments. The procedures described are communication doctrine, radiotelephone and telephone and

switchboard practices. The two volumes of the IEMCAP user's manual describe the program, its organization, analytic basis, operating principals, logic flow and detailed instructions on how the program is used.

A. Measurement Technique Development

The application of measurement techniques will be to perform the following types of tests:

- Measure the conducted spectrum of an emitter port.
- Measure the radiated emission spectrum of an equipment case.
- Measure the integrated conducted level of a receptor port.
- Measure the integrated current level in a wire bundle.
- Measure integrated field strengths at a point in space.
- Measure radiation fields of an antenna.
- Determine the conducted susceptibility of a port.
- Determine the radiation susceptibility of an equipment.
- Determine the "susceptibility" of a wire bundle to inducted currents. The susceptibility refers to that of all receptor equipment connected to the bundle.
- Determine the radiation susceptibility of receiving equipment to antenna coupled signals.
- Measure characteristics of a coupling path between two given points in the system.

The procedures to be developed and applied for these categories are intended to enable the collection of data more quickly without sacrificing accuracy. For the emission tests, both automated and broadband measurement techniques provide the means for fast and accurate measurements. The automated measurement techniques are well established for emission tests in the range of DC to 12 GHz. Broadband measurement techniques are technically feasible; however, appropriate hardware must be developed for this type of testing. Susceptibility measurements do not lend easily themselves to automated or broadband techniques because of the requirement for observation of degradation to an equipment, which usually requires human observation and judgment.

Work in the first quarter was concentrated in reviewing automated measurement techniques and how they apply to MIL-STD-462 procedures and to the types of data required for the analysis-directed MIL-STD-462 testing required by the testing proposed in this task. Two conclusions have been reached with respect to this work. First, the automated measurement techniques used in EMI/EMC testing do, in general, provide a good capability for the testing proposed in this task especially for emission tests. Second, a good data base of equipment parameters will be necessary in order to take full advantage of the analysis-directed measurement procedures. This data base for equipment parameters will require more information than is now produced by present required practices. The MIL-STD's are being studied to determine whether the data produced by the present procedures and techniques are useful in an analysis-directed program. It is clear that a good EM data base for the subsystems and equipments is necessary to perform the analysis and thereby assist in the formulation of EMI/EMC tests fr the overall system. Present testing practices, as specified in the MIL-STD's, do not produce all of the required EM data in the most efficient manner. Modifications to the established procedures are being formulated and will be presented along with the data base requirements for an analysis-directed EMI/EMC system test in later stages of this task.

One aspect of producing system, subsystem, and/or equipment EMI/EMC data is a more useful and efficient manner, especially in producing the required background data base, by using broadband measurement techniques. This method requires the determination of emission peak levels over at least one cycle period of the data using a wide bandwidth. These data are then processed in a high-speed digital computer using a Fast-Fourier Transform and digital filtering. This technique is very fast but the dynamic range of the data collected is reduced. The dynamic range achievable with various bandwidths will be compared to the emission and susceptibility limits of MIL-STD-461A.

B. Analysis Program Review

Review of IEMCAP has been started to determine what type of data is necessary to perform a meaningful system analysis leading to the direction of the EMI/EMC measurement effort. The system physical data, such as cable and component placement, are most important. Emission and susceptibility data for subsystems and equipment are also a required input. IEMCAP analysis will point out EMI/EMC vulnerability points in the system at various frequencies. This analysis, however, will only be as good as the data fed into the program. In order for IEMCAP to be a useful tool the data base used as an input must be very accurate.

5.0 WORK PLANNED FOR SECOND QUARTER

In the second quarter, the IEMCAP feasibility satudy will be completed and an evaluation statement of its applicability to U.S. Army complex system EMI measurements will be included in the second quarterly report. If the use of IEMCAP is judged feasible then its integration as a component part of the EMI measurement procedures will be demonstrated. However, even if IEMCAP feasibility is established, research into other available analysis techniques will be continued.

Work will continue in the development of measurement techniques with attention toward expanding to the definition of instrumentation. This will involve the broadband measurement techniques where an effort is being made to establish the hardware required for the measurement. Once the hardware is identified, the dynamic range of the system will be described from the nominal parameters for the hardware. The dynamic range will be compared to the emission and susceptibility levels of MIL-STD-461A. Instrumentation for EMI/EMC measurements above 12 GHz will also be investigated. Automated EMI/EMC measurement test sets presently being used will be evaluated.

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Mr. John Spina RADC/RBCT Griffiss AFB, NY 13441	01
Commander US Army Communications Research & Development Command ATTN: DRDCO-SEI-A/Mr. Sam Segner Fort Monmouth, NJ 07703	01
Commander US Army Communications Research & Development Command ATTN: DRDCO-COM-D Fort Monmouth, NJ 07703	01
Commander US Army Communications Research & Development Command ATTN: DRDCO-COM-RY-3/Mr. Stuart Albert Fort Monmouth, NJ 07703	15